# OBSERVATIONS ON THE YELLOW-BILLED TROPIC-BIRD (*PHAËTHON AMERICANUS* GRANT) AT THE BERMUDA ISLANDS.

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*Plates III–XI.*

CONTENTS.



THIS paper is based upon studies made while at the Bermuda Biological Station from June 17 to August 2, 1910, and from June 26 to August 5, 1911. It is a pleasure here to acknowledge my gratitude to Prof. E. L. Mark, director of the Bermuda Station, for many valuable suggestions and for revising the manuscript.

The geographical location of the Bermudas is unique, in that they are in mid-ocean about seven hundred miles from the nearest land. The longitude of the center of the group is 64° 39′ 53″ W.,

[1] Contributions from the Bermuda Biological Station for Research, No. 23.

about that of Halifax, and the latitude 32° 15′ 23″ N., or about that of Charleston, S. C., and of Los Angeles, Cal. The islands are nearly equi-distant from Halifax, New York, Charleston and the nearest of the West India Islands. The extreme isolation of the Bermudas is a fact of the utmost importance in considering its animal life, and especially its bird life, for the islands lie outside the courses of the great migration routes of the main land. As a consequence relatively few birds regularly visit the islands during the spring and fall migrations.

The Bermudas embrace over 150 islands, but the majority of these are extremely small and not inhabited by man. They form a long, narrow, hook-shaped group, which if placed in a straight line would reach not more than 15 to 20 miles. The width of this hook varies from one half mile to two miles. The total area of dry land is between 19 and 20 square miles, but the coral reefs extend over a much greater area. From the top of Gibb's Hill lighthouse, one of the two lighthouses of the islands, the ocean can be seen on all sides.

The vegetation is semi-tropical, but there is a predominance of second-growth cedars, which give the islands an appearance not unlike that which one may see on our own New England coast (Plate III, fig. 1). The majority of the larger islands are covered with these cedars, among which are interspersed clusters of palmetto palms. In the parks and private estates there are cultivated many trees, such as the royal, sago, cocoanut and grugu palms, the royal poinceana, the rubber tree, the pawpaw, etc. These give a decidedly tropical effect to certain sections of the islands. Since only a small part of the land is under cultivation, there are many neglected areas where the vegetation takes its own course, thus forming ideal resorts and nesting sites for many of the land birds. Along the low-lying shores of some of the inlets and bays are narrow but impenetrable thickets of mangroves, which are also a rendezvous for many birds, especially during the hot hours of the day. Mention should also be made of the luxuriant oleanders, which are in the prime of their beauty and fragrance during June and July. There are few features of the vegetation which contribute more to make these beautiful islands charming and attractive.

The greater part of the dry land of the islands consists of a limestone made up of the wind-blown fragments of shells and corals firmly cemented together. This rock is easily eroded, but when a fresh surface is exposed to the action of the weather for some time, it becomes hard and resistant. The shores of many of the islands are precipitous or overhanging cliffs, which have been honey-combed by the incessant action of the surf or the solvent effect of rains. It is among the recesses and caves of these cliffs that the Tropic-birds of Bermuda nest and rear their young.

The Yellow-billed Tropic-bird, *Phaëthon americanus*, locally known as the Boatswain Bird, or the Long-tail, is the only one of the two species of Tropic-birds of the West Indies which visit the Bermudas. These birds are tern-like in appearance and manner of flight, although belonging to the order Steganopodes. The gular pouch, which is characteristic of the Steganopodes, is entirely feathered and much reduced in size in the Tropic-bird, but it nevertheless functions as a pouch in the process of feeding.

The plumage of the adult Tropic-bird is a satiny white with the following prominent black areas: a spot in front of, and slightly below, the eye, which is continued backward as a narrow band through the ocular region; a large oblique band on the lesser wing coverts and extending thence on to the scapulars and inner secondaries; patches on the outer shafts of 5 or 6 of the primaries; and stripes on the flanks. The black markings on the primaries and secondaries are very conspicuous when the bird is seen in flight. The iris is dark brown, the tarsus bluish, and the toes and webs jet black. The bill varies from pale yellow to bright orange-red, depending on the age of the bird. The tail is extended into two very long central feathers, which are of variable length and color. In adult birds these feathers have a marked tinge of russet brown or dull salmon, but no individuals were seen in which there was a distinctly reddish color, such as is frequently described. In a very few there was a roseate tinge to the plumage, which was accentuated on the feathers of the neck and breast. There is no consistent variation in color or measurements which can be correlated with sex. The measurements of eight specimens are as follows:

| | Sex | Length cm. | Tail cm. | Extent cm. | Wing cm. | Bill cm. | Foot cm. | Weight grams. |
|---|---|---|---|---|---|---|---|---|
| 1. | ♂ | 74.0 | 48.3 | 90.1 | 27.2 | 5.3 | 6.6 | 398 |
| 2 | ♀ | 64.3 | 36.8 | 91.5 | 27.1 | 5.1 | 6.4 | 425 |
| 3. | ♂ | 49.2 | 22.1 | 90.7 | 28.1 | 5.2 | 6.2 | 465 |
| 4. | ♀ | 43.1 | 15.1 | 89.1 | 27.1 | 4.9 | 6.5 | 402 |
| 5. | ♂ | 48.7 | 20.4 | 91.6 | 27.5 | 5.0 | 6.4 | 367 |
| 6. | ♂ | 54.0 | 21.8 | 88.5 | 27.8 | 5.0 | 6.9 | 385 |
| 7. | ♀ | 44.2 | 15.0 | 96.2 | 28.1 | 5.4 | 6.7 | —— |
| 8. | ? | 62.5 | 32.4 | 91.5 | 27.4 | 5.5 | 6.8 | —— |

The variation of the tail measurement is very great in the above series, since nearly all of the specimens are of nesting birds, in which the longer of the two long tail feathers are frequently frayed or broken or even absent.

The geographical range of the Yellow-billed Tropic-bird includes the islands of the West Indies; it extends as far west as Central America, and north to the Bermudas. The following records of its occurrence in the United States have also been reported: One on the coast of Nova Scotia, September 4, 1870;[1] one in the interior of Nova Scotia after a violent storm, in September, 1870;[2] an immature specimen captured in Orleans Co., N. Y., 1879;[3] and one shot on the Banana River, Florida, April 21, 1886.[4] A few others have been reported off the coast of Cape Hatteras[5] and the coast of Florida.[6] Their occurrence in the United States is rare, and none have been found to breed on our shores.

The Tropic-birds migrate from the West Indies and, except for occasional stragglers, none are to be found in the Bermudas during the winter months. This annual migration flight is remarkable when it is considered that the birds must necessarily fly over open water for a distance of more than 600 miles without any landmark to guide them. The first Tropic-birds appear at the Bermudas during the latter part of February, according to fishermen and local observers, but the great bulk of them do not arrive until the first weeks of March. Mr. Mowbray, Superintendent of the Bermuda Aquarium, while making a voyage to Turk's Island in

[1] Reid, Bulletin U. S. Nat. Museum, 1884, vol. 25, p. 264.
[2] Gilpin, Orn. and Oö., 1882, vol. 7, p. 123.
[3] Coues, Bulletin, Nutt. Ornith. Club, 1880, vol. 5, p. 193.
[4] Brewster, Auk, 1886, vol. 3, p. 481.
[5] Gault, Wilson Bulletin, 1902, vol. 9, p. 141.
[6] Lawrence, Pacific R. R. Reports, 1858.

1909, saw on February 9 and 10 several groups of 2 or 3 individuals each, which were flying in a direct course for the Bermudas. This agrees with the supposed course of migration of the Tropic-birds and illustrates the keen sense of direction and orientation which they must possess. These birds would probably be admirable subjects for experimenting on orientation.

When we arrived at the islands, June 17, 1910, and June 26, 1911, the birds were in the midst of their nesting activities. During the early morning hours many of them could be seen in the vicinity of their nesting sites gracefully circling and wheeling high above the surface of the water, with their long graceful tail feathers streaming out behind. As the birds flew back and forth over the sound, their pure white breasts and underparts reflected the bright emerald green of the water, in such a manner as to give their plumage a distinctly greenish appearance. The effect thus produced under certain conditions of light is very deceiving even to an experienced observer.

The food of the Tropic-bird consists chiefly of marine animals, which in the majority of cases are secured by diving. The birds go on long foraging flights, wandering, according to some observers, as far as 50 miles from land. On our return trip to New York in 1910 a lone individual was seen which was estimated to be 150 miles distant from Bermuda, and on June 25, 1911, I saw two of these birds which were 200 miles from land. These are probably extreme cases, but they serve to illustrate the unusually long excursions which the Tropic-birds may make in their search for prey.

The food contained in the gullets and stomachs of 5 adult specimens was made up, for the greater part, of squids and fishes, especially small minnows. In one of the stomachs there were a few fragments of a crab and a sea urchin, as well as particles of material which could not be identified. Two of the five kinds of fishes found belonged to species of flying fish (*Exocœtus furcatus* and *Exonautes exsiliens*) which are common in the waters of Bermuda. It would be interesting to know whether or not these flying fish are captured while they are sailing above the surface of the water. The food delivered to the young varies with the age of the nestling, therefore is best considered in connection with the account of the young birds.

The adult birds are most active during the early morning hours; it is only occasionally that they can be seen feeding during the middle of the day, the heat at that time being perhaps great enough to account for the diminution in their numbers. A few of my notes taken July 8–9, 1910, when two of us spent the night on Morgan's Island, may serve to show something of the usual activities and how they are related in time to the activities of other birds. Morgan's Island is one of the several islands at the entrance of Ely's Harbor. The limestone cliffs on the seaward side constitute one of the most extensive and accessible rookeries of the Tropic-bird to be found in Bermuda, hence an ideal place for studying the habits of both old and young birds. My notes are as follows:

"July 9, 3:30 A.M. The first bird note heard is the clear ringing whistle of the Cardinal, which is roosting among the palmettos.

"4:00 A.M. The Catbirds are beginning to tune up.

"4:20 A.M. The White-eyed Vireos are joining the Catbirds in the oleanders.

"4:30 A.M. Dawn approaching rapidly; the distant upper clouds are reflecting the light of the morning sun.

"4:50 A.M. In the cedars, European Goldfinches are beginning to sing, but their notes can scarcely be distinguished in the exuberant chorus of other songsters.

"5:00 A.M. Sunlight to be seen on the trees of the hilltops.

"5:05 A.M. First Tropic-bird leaves the cliff.

"5:10 A.M. At some distance from our hiding place two more Tropic-birds appear.

"5:20 A.M. Tropic-birds are leaving the nests situated close about us. Some of them apparently have discovered our presence and are showing signs of uneasiness.

"5:45 A.M. At some distance out at sea an adult bird makes a perpendicular dive into the water from a height of about 50 feet.

"6:00 A.M. Many Tropic-birds are flying about on the sea side of the island. Birds are constantly leaving or returning to their nests.

"6:25 A.M. Songs of the land birds diminishing in volume.

"6:30 A.M. About 50 Tropic-birds can be seen at one time in the immediate vicinity of the cliffs and many others are either going out or returning from the sea."

The numbers remained practically constant until about 8:30 A. M., when there was a uniform, but rapid decrease, and by 11:00 A. M. there was only an occasional Tropic-bird to be seen flying about. The birds were again active during the few hours before sunset, but the numbers at this time never equalled those of the morning hours.

The diving of the Tropic-bird is remarkable in that the plunge is usually made from a height of 50 feet or more above the surface of the water. The bird after sighting its prey poises a second or two in mid-air by rapidly vibrating the wings, meanwhile maintaining a gaze on its victim. It then turns quickly at right angles and with wings folded darts through the air with the swiftness and precision of an arrow. Frequently this downward plunge takes the form of a spiral descent. It is uncertain whether this spiral course is the result of a voluntary act or not.

Nests of the Tropic-bird were found in favorable places among the cliffs at Ely's Harbor, Hungry Bay, Tucker's Town, Harrington Sound, Castle Harbor, Spanish Point and on nine of the islands of Great Sound. Verrill [1] estimated that 2000 pairs were breeding in the islands in 1901. Apparently the numbers have not changed very much since that time. The majority of the nests found during the latter part of June contained either eggs or else young in well advanced stages of development. This fact, correlated with the time of arrival of the birds and the period of nesting, indicates that there are probably two nesting periods in a season. Buckenham [2] states that several broods are reared during the year. There are doubtless two, but certainly not more than two, broods in a season reared by these birds while in the Bermudas.

Particular localities, especially on the south shore of the main island, seemed to be preferred by many of the birds. At Ely's Harbor and Tucker's Town it was not unusual to find as many as 50–75 pairs nesting within a range of less than 100 yards. The Tropic-birds are not, however, strictly gregarious, for isolated nests about the islands of the sound were very common. The so-called colonies probably exist because of the many choice nesting

[1] The Bermuda Islands, 1901–03, p. 680.
[2] Museum, 1894, pp. 15–16.

sites which chance to be situated in the particular locality, rather than to any gregarious or social instinct on the part of the birds.

The nature of the nesting site varies from that of the open places on the shelf-like ledges to that of the inner end of a narrow and circuitous passage, or the recesses of an obscure cave. In the two latter situations the presence of the adult bird may often be ascertained by inserting a long pole into the opening, which usually brings forth a shrill cry in response to the intrusion. At Tucker's Town nests were found in shallow excavations in the side of a high sand dune which ran along the shore. These cavities, which apparently were made by the birds themselves, were in each case at the base of some herbage, which to a certain degree shielded and protected the bird from the intense heat and light of the sun.

The height of the nest above the water varies greatly; it ranges from a point just above the high water mark to one situated near the top of the highest cliffs, perhaps 75 or 100 feet above the sea. At Ely's Harbor some of the nests were so low that during an unusually high tide accompanying a storm, they were overwashed by the waves and filled with heaps of sargassum and other sea weeds. The sargassum is found in many of the lower open nests, where it is deposited by the giant waves during the severe tempests of the winter months. No nesting material is ever collected by the birds, but the single egg is deposited on the bare rocks or else on the mat of sea weeds already present.

The nests most favorable for study and photography are those which are exposed to view and are open to the light, but unfortunately these are the ones most liable to destruction by the elements or by natural enemies. As a consequence nests in shallow but well protected cavities, from which the eggs and the young could be easily removed from time to time, were more desirable, being less liable to molestation. Nine such nests located on four of the islands of the sound near to the laboratory on Agar's Island were chosen for daily observations on the growth and development of the young. On Agar's Island a large observation box was constructed within four feet of a nest, from which more minute observations of the feeding habits could be made.

The eggs are extremely variable in their coloration and markings. In general they have a chalky white or creamy groundwork thickly

spotted with three colors: chestnut, chocolate brown, and purplish red. The spotting is usually more dense at the larger end and quite often presents a blotched or smeared appearance (Plate VI, fig. 8). On other specimens the distribution of markings is more uniform, there being no predominance of color at the larger end (Plate VI, fig. 7).

The chocolate color is easily rubbed off, especially when the egg is first immersed in water. Even the contact of the bird's body during incubation may remove more or less of the color.

The measurements of 8 eggs collected form various parts of the islands are as follows,—

| | Longest diameter cm. | Shortest diameter cm. | Weight grams |
|---|---|---|---|
| 1. | 4.9 | 3.6 | 37 |
| 2. | 5.1 | 3.6 | 35.2 |
| 3. | 5.2 | 3.8 | 39 |
| 4. | 5.2 | 3.6 | 38 |
| 5. | 5.4 | 3.9 | 44 |
| 6. | 5.6 | 4.1 | 40.9 |
| 7. | 5.7 | 3.8 | 44 |
| 8. | 5.8 | 3.7 | 45 |

The incubated egg weighs slightly less than the fresh egg.

The birds copulate in the recesses of the cliffs and apparently in the niche eventually to be used as a nesting site. At Bethel's Island I found two pairs copulating in different places in the rocks. In one case the female was bleeding about the head from wounds made by the male in his desperate attempts at holding the bird during copulation. Both females presented a somewhat mussed and haggard appearance. During the four days elapsing before the next visit to the island, eggs were deposited in these nests, and in all probability by the females previously observed. Several other pairs of adult birds were found together, but in these cases there was no evidence of copulation and no clew for the identification of sex.

Both the male and female birds take part in incubation, and during this period the egg is seldom left uncovered for more than a few minutes. The birds take their turns at the nest, thus giving each other an opportunity to feed. In one case an adult was seen feeding its mate while the latter was brooding the egg.

The period of incubation was not accurately ascertained, since the exact dates of the laying of the eggs under observation was not determined. One egg, which seemed fresh when found, required 28 days of incubation for the young to emerge. Other eggs under daily observation required from 15–25 days, but evidently these had been incubated some days when first observed.

The shell membranes of the eggs are resistant and leathery, a condition well adapted to withstand the sharp points of the stones and the hard barren surfaces on which the single egg is usually deposited. The young require considerable time to rupture this membrane even after the egg is pipped and fragments of the calcareous shell are broken away (Plate VI, fig. 9). In one, perhaps unusual, case the egg was pipped and the "peep" of the contained embryo was heard 42 hours before it had completely emerged.

The adult birds became accustomed to my frequent visits to their nests and allowed me to stroke them or to remove the egg without any sign of resistance. At the hatching of the egg, however, there was a profound change in the behavior of the parent birds.

The presence of the little one seemed to incite in them a ferocious antagonism against any intruder, and it was only with the greatest care and precaution that the little one could be safely removed for study. After some time had elapsed the parent birds seemed to adjust themselves to the new conditions and were approached with less or no opposition.

Nesting birds, although not accustomed to regular visits by any one, would allow an observer to operate a camera within a few feet of them, if care were taken to make no quick or unexpected movements. If the intruder approached nearer, the bird bristled up its feathers, spread its wings, and responded with a quick thrust of its sharp beak. After repeated annoyance the parent bird will leave the nest, an act, however, which it seems very averse to doing. This reluctance may be due to its helplessness while on its feet. The birds never walk upright, but the body is shoved along in a cumbersome manner by their diminutive legs. The wings are often brought into service for supporting and balancing the comparatively heavy body, which is scarcely raised above the surface on which the bird is moving (Plate IV, fig. 3). On first leaving the nest the adult bird leaps from the ledge and nimbly catches

itself on the wing, but sometimes, especially after being irritated or excited, it may fall to the water before taking flight. When once poised in the air, the Tropic-birds may be classed with the most graceful of sea birds. They have a very characteristic movement when flying, which is very unlike any other bird I know. Although these birds allow one to approach while on their nests, they are very cautious in returning to the nest if there is any suspicion of the presence of a human being in the immediate vicinity.

Among the enemies of the Tropic-birds are the colored natives, who molest the nests of the birds in spite of the stringent bird laws of the islands. It is probable the eggs collected are used as food. The robbing of nests for such purposes is said to be common in the West Indies. The wood rat (*Mus alexandrinus*), however, is responsible for some of the mysterious disappearances of the many eggs I had under observation. On one of my daily rounds to the nests on Two-Rock Island I caught one of these rats in the act of sucking an egg. The greedy creature was allowed to finish his meal, after which he was killed and preserved as evidence against his kind. I saw no other rats in the act of molesting eggs, but no doubt they find the Tropic-bird eggs a convenient source of food.

All of the Tropic-birds examined were infested with at least a few and sometimes with thousands of mites, of which there were three species at least. These mites never appear to be fatal to the bird, but nevertheless they must cause a disagreeable irritation when numerous. They feed upon the barbules of the feathers and in some instances this injury to the feathers may be so extensive as to cause a noticeably rough appearance of the plumage. Three species — identified by H. E. Ewing of Cornell University — were found in great abundance on some of the skins. *Docophorus breviantennatus* Piaget, belonging to the Mallophaga, is a large black form, which is very conspicuous when seen on a background of pure white feathers. The two species of true mites are *Alloptes microphaethon* Frb., and *Alloptes longipes. n. sp.*, belonging to the family of Analgesidæ. The new species, *Alloptes longipes*, is described by Dr. Ewing in Psyche, Vol. 18, No. 1, p 41.

## III. Life History.

In the study of the life history of the Tropic-bird I was somewhat handicapped, since the life of the young spent in the nest extends over a peroid longer than the time at my disposal during either summer in Bermuda.

However, there was an abundance of material near the Biological Station, which enabled me to secure measurements, descriptions and photographs of every phase of their development. Daily observations and measurements were made of five birds of various ages, two of which are at either end of a complete series. By a careful comparison of the measurements (see Table, pp. 61–62) and descriptions of these two birds, it was possible to match them at the 33rd day of development. In making these comparisons the measurements of the tail, wing, bill, and foot were given greater weight, since these measurements seem to be more constant for different individuals of the same age. Furthermore, it is extremely difficult to measure accurately the extent and length of an active living bird, which never fails to offer great resistance to such a procedure. If the comparisons are correct, the length of time spent by the young Tropic-bird in the nest extends over a period of 62 days, or about two months. The time required for incubation, previously noted, is about 4 weeks, making the complete period about 3 months. The adult birds remain in the islands about 7 months, which affords them ample time to rear two broods, but not more, during any one summer in Bermuda. The following records of three of our land birds are interesting in comparison with those of the Tropic-bird.

| | Time required for incubation. | Time spent by the young in the nest. | Total. |
|---|---|---|---|
| Finch [1] | 9 days | 10 days | 19 days |
| Flicker [2] | 12 days | 25–28 days | 37–40 days |
| Golden Eagle [1] | 30 days | 90 days | 120 days |

The measurement of extent in the freshly hatched bird is less than the length, but this relation is reversed at the end of the 6th day, and by the time the young bird is ready to leave the nest the extent becomes three times the length minus the tail or more than

[1] W. L. Finley, American Birds, pp. 245–246.
[2] A. R. Sherman, Wilson Bull., 1910, pp. 135–171.

twice the total length. Furthermore, the wings undergo their greatest development during the last few weeks spent in the nest, while the feet grow but little after the first month. This seems a most favorable condition in view of the fact that the feet are functional and necessary from the very beginning of the free life, while an extensive development of the wings in the early part of the life history would prove a great inconvenience.

TABLE OF MEASUREMENTS.

| Age, days. | Length, cm. | Tail, cm. | Extent, cm. | Wing, cm. | Bill, cm. | Foot, cm. | Weight, grams |
|---|---|---|---|---|---|---|---|
| 1 | 11.9 | | 11.2 | 1.6 | 1.2 | 2.8 | 25 |
| 2 | 12.4 | | 11.3 | 1.7 | 1.2 | 2.8 | 28 |
| 4 | 12.7 | | 11.9 | 1.8 | 1.3 | 2.8 | 35 |
| 5 | 13.2 | | 12.6 | 2.0 | 1.3 | 3.0 | 49 |
| 6 | 14.0 | | 14.2 | 2.3 | 1.3 | 3.3 | 54 |
| 7 | 14.6 | | 15.3 | 2.4 | 1.4 | 3.4 | 66 |
| 8 | 16.1 | | 16.7 | 2.5 | 1.4 | 3.6 | 92 |
| 10 | 16.9 | | 18.5 | 2.8 | 1.5 | 3.8 | 86 |
| 11 | 16.9 | | 19.6 | 2.8 | 1.6 | 3.9 | 72 |
| 12 | 17.8 | | 20.1 | 3.0 | 1.7 | 4.1 | 146 |
| 13 | 18.7 | | 22.1 | 3.1 | 1.9 | 4.2 | 128 |
| 14 | 19.2 | | 24.3 | 3.2 | 1.9 | 4.5 | 157 |
| 15 | 20.1 | | 25.4 | 3.5 | 2.0 | 4.7 | 145 |
| 16 | 21.0 | | 26.2 | 3.7 | 2.1 | 4.8 | 127 |
| 17 | 21.0 | | 26.7 | 3.9 | 2.2 | 4.8 | 121 |
| 18 | 21.8 | | 28.6 | 4.6 | 2.3 | 5.2 | 173 |
| 20 | 22.9 | | 32.5 | 5.5 | 2.4 | 5.4 | 232 |
| 21 | 23.0 | | 33.9 | 5.8 | 2.6 | 5.5 | 267 |
| 22 | 24.1 | .4 | 36.1 | 6.2 | 2.7 | 5.6 | 253 |
| 24 | 24.3 | 1.0 | 37.6 | 6.9 | 2.9 | 5.6 | 250 |
| 25 | 25.9 | 1.5 | 40.7 | 7.2 | 3.0 | 5.7 | 303 |
| 27 | 26.9 | 1.9 | 43.0 | 8.0 | 3.1 | 5.8 | 302 |
| 28 | 27.4 | 2.4 | 45.1 | 8.7 | 3.2 | 5.9 | 321 |
| 29 | 27.6 | 2.6 | 46.6 | 9.4 | 3.3 | 6.0 | 349 |
| 30 | 27.9 | 3.1 | 48.6 | 10.1 | 3.4 | 6.1 | 325 |
| 31 | 28.7 | 3.2 | 49.8 | 10.4 | 3.5 | 6.1 | 359 |
| 32 | 29.1 | 3.5 | 51.6 | 10.8 | 3.6 | 6.1 | 353 |
| 33 | 29.9 | 3.7 | 52.9 | 11.2 | 3.6 | 6.1 | 348 |

TABLE OF MEASUREMENTS (*Continued*).

| Age, days. | Length, cm. | Tail, cm. | Extent, cm. | Wing, cm. | Bill, cm. | Foot, cm. | Weight, grams. |
|---|---|---|---|---|---|---|---|
| 34 ? | 29.8 | 3.8 | 57.8 | 11.5 | 3.7 | 6.0 | 357 |
| 36 ? | 31.1 | 4.1 | 59.1 | 12.6 | 3.8 | 6.1 | 355 |
| 37 ? | 31.5 | 4.5 | 60.2 | 13.1 | 3.8 | 6.2 | 377 |
| 38 ? | 32.3 | 4.9 | 62.8 | 14.2 | 3.9 | 6.2 | 390 |
| 39 ? | 33.0 | 5.6 | 64.7 | 15.7 | 4.0 | 6.3 | 422 |
| 41 ? | 34.5 | 7.1 | 70.4 | 17.5 | 4.2 | 6.3 | 570 |
| 48 ? | 39.4 | 10.1 | 80.7 | 21.6 | 4.3 | 6.4 | 510 |
| 52 ? | 40.6 | 11.2 | 82.4 | 22.2 | 4.4 | 6.5 | 497 |
| 57 ? | 41.4 | 13.1 | 83.2 | 24.2 | 4.6 | 6.5 | 499 |
| 60 ? | 42.6 | 13.7 | 86.1 | 24.6 | 4.6 | 6.6 | 467 |
| 62 ? | Left the Nest. | | | | | | |
| Average growth per day. | .520 | .380 | 1.269 | .390 | .058 | .064 | 7.58 |
| Percent of total growth accomplished, on the average, each day. | 1.69 | 2.86 | 1.69 | 1.70 | 1.71 | 1.68 | 1.71 |

The above table of measurements is made from the studies of two birds which stand one at either end of the series. The two life histories seem to overlap but match comparatively well at the 33rd day of development. The age of the older bird is only approximately known (within 4 or 5 days), since the measurements of different young of the same age may vary as much as the growth of four or five days.

The weights of the young birds fluctuated a great deal from day to day; this was due to the fact that they were weighed in the morning after feeding time. A series of weighings made during the night, or very early morning before any food has been received by the young birds, would undoubtedly be less variable.

One of the young at the time of hatching when thoroughly dry and before it was fed weighed 25 grams, or 19 grams less than the egg from which it hatched. Another young bird weighed on the day of hatching 30 grams; but this individual was not watched and therefore it may have received food.

The food of the young during the first 10 or 15 days consists of snails and soft marine animals. In some cases it seemed to be

merely the regurgitated juices and semidigested food from the gullet of the parent bird. When the birds are between 15 and 30 days old, more than 90 % of the food consisted of squids, the remainder being made up of small minnows and some unidentifiable material. During the latter half of the young bird's life fish constitutes a large part of the food, although many squids, some of considerable size, were present in nearly every specimen examined.

It was not necessary, in most cases, to kill the bird in order to make an examination of the food, for the young birds, especially those of an age in which the instinct of fear was acquired, violently regurgitated their food on the slightest provocation, even the mere handling of the birds unaccustomed to my visits would cause them to throw up the entire contents of their gullets. By taking advantage of this simple means, it was easy to gain information about the food without causing the birds any serious injury. Below are lists of the animals, with their weights, which were found in five such regurgitations of different birds ranging from 30 to 50 days old, arranged in the order of the ages of the birds, No. 1 being the youngest.

*No. 1.*

| | |
|---|---|
| Squid | 17 grams. |
| " | 11.1 " |
| Minnow | 2.4 " |
| | 30.5 grams. |

*No. 2.*

| | |
|---|---|
| Squid | 16.9 grams. |
| " | 16.7 " |
| " | 3.1 " |
| | 36.7 grams. |

*No. 3.*

| | |
|---|---|
| Squid | 13.1 grams. |
| " | 10.1 " |
| " | 9.0 " |
| " | 2.5 " |
| " | 3.0 " |
| Minnow | 2.1 " |
| | 39.8 grams. |

*No. 4.*

| | |
|---|---|
| Squid | 27.3 grams. |
| " | 16.8 " |
| " | 14.5 " |
| " | 6.5 " |
| " | 5.7 " |
| Flying Fish (part) | 4.5 " |
| Fragments | 3.2 " |
| | 78.5 grams. |

*No. 5.*

| | |
|---|---|
| Squid | 22.5 grams. |
| " | 9.5 " |
| Flying Fish | 10.0 " |
| " " | 9.0 " |
| " " | 7.5 " |
| 4 minnows and fragments | 26.5 " |
| | 85.0 grams. |

The amount of food regurgitated by No. 4 and No. 5 may seem excessive, since it equals about $\frac{1}{5}$ to $\frac{1}{6}$ of the total weight of the bird, yet such quantities of food in one gullet were not unusual. Since the birds ordinarily are fed only during the early morning hours, one should expect to find large quantities of food delivered at this single meal. The squids, which, as we have said, make up the largest part of the food of the young, as they also do that of the adult birds, are probably captured out at sea, for I saw very few squids when making collections of marine animals about the islands. Thousands of squids are eaten each day by these birds, so there must be an enormous quantity of them in the vicinity of their feeding grounds.

The young birds become very fat and heavy during the last 10 or 15 days of their life in the nest, and in all cases under observation they weighed more at this stage than the heaviest of the adult birds. This storing up of substance which may later serve as food prepares them to withstand the strenuous ordeal required of them upon leaving the nest.

At the time of hatching, the young Tropic-bird is to all appearances a ball of fluffy down with its dark colored beak and black feet standing out in marked contrast to the background of white (Plate VII, fig. 11). It is only the region about the beak, the underparts, and the middle of the back which are pure white, for the remainder of the plumage, especially the crown, sides of the back, and region of the wings has a decided tinge of dull gray.

The eyes of the nestling remain closed for one or two days, but the young birds are very active and responsive from the very beginning. A mere touch, or even the click of the camera, is enough to incite the creature to extend its neck and open its beak in eager anticipation of some lucious snail or other appetizing morsel of food. In taking pictures of some of these birds, it was necessary to click the shutter several times before attempting the final exposure, in order to avoid the gaping attitude.

At the end of the fourth day (Plate VII, fig. 12) the birds have their eyes fully opened, but they blink incessantly when brought out to the open light.

During the first ten days of life in the nest the chief changes which occur are concerned with size, for no feathers appear during

this stage of the nestling. The beak becomes lighter in color, but the skin in front of the eyes (lores) and at the base of the upper mandible (front) remains jet black. The tarsus is bluish, but the toes and webs are black, as in adult birds. The down on the breast is much shorter and denser than elsewhere, thus forming a firm mat, which protects the tender body from the sharp stones or rough surface of the rock on which the bird is usually obliged to rest. A characteristic pose of the bird at this age is one with its body and head outstretched on the bottom of the nest (Plate VIII, fig. 14). This position was frequently assumed whether the bird was awake or asleep. The young showed no evidence of fear during the first two weeks, for when I approached the nest, they did not seem to be afraid of me. Often when I placed my hand near them they would pick at my fingers as if testing some new and strange kind of food. The young birds which I visited daily never developed an instinct of fear; but, on the contrary, as they grew older they seemed to be pleased to have me make a call during the long hours when they were left alone.

The adult birds remain very closely with the young during the first ten days. The little fellow is usually tucked in under the feathers of the adult and frequently sleeps with its head projecting through the feathers, just as a little chicken does when it is brooded by the old hen. When the little creature became restless the old bird uttered a series of low guttural sounds, which, I assume, were intended as disapproval.

At the end of the 16th day were seen the first feathers. They made their appearance on the scapular region of the spinal tract (Plate VIII, fig. 14). By separating the down, the tips of the bluish colored sheaths of the feathers may be seen projecting through the dark skin. The feathers grow rapidly, soon lose their sheaths, and by the 20th day are well expanded, producing a conspicuous patch of black-and-white barred feathers (Plate IX, fig. 15). By this time the sheaths of the feathers of the breast, the primaries, secondaries, and tail feathers appear, but they do not show through the coat of down until several days later. During the first twenty days the bill assumes more and more the shape and proportions of that of the adult. Its dark bluish color changes to a white or flesh color, but the tip of the mandibles retains a

brownish tinge. The skin about the base of the upper mandible and the lores remains jet black and is devoid of down or feathers at this age.

From the 20th to the 35th day marked changes in the plumage occur. At the end of the 25th day the developing wing feathers are so heavily charged with blood that the nestling is unable to support its wings continuously (Plate IX, fig. 16).

By the end of the 35th day the wing feathers, including the coverts, are well expanded and now form with the scapulars, which were the first feathers to appear, a continuous band. The down gradually frays away as the feathers replace this first protective covering.

The tail feathers are well advanced during this period, and by the 35th day the two central tail feathers, destined to become the long feathers in the tail of the adult, attain a length of 4 cm. The feathers of the head and rump, although sprouted, do not show through the coat of down; so, when the bird is viewed from the side it displays alternate areas of down and feathers (Plate X, fig. 17). The feathers of the breast become well expanded at the 37th day and with the down form a veritable feather mattress, on which the bird rests or crawls about the nest (Plate X, fig. 18). The feathers about the base of the beak have appeared and now completely conceal the dark skin. The black loral spot, so conspicuous in the adult, is now well differentiated.

The adult bird spends less time with the young as the latter becomes older, at least this is true of the birds which were under continual observation. After the 20th or 25th day the young bird on Agar's island was visited by the parent bird only during the morning at feeding time. The adult bird usually appeared about 6 o'clock and after 2 or 3 visits was seen no more until the next day. After being fed the young bird settled down for a profound sleep, but at irregular intervals, from some unknown impulse, it would suddenly arise, stretch its wings, preen its feathers, and then settle down again for another nap. In the afternoon the young bird was usually awake and would amuse itself by picking at the stones about the nest, or perhaps would snatch at the flies or gnats which were often abundant in the vicinity of the nest. At other times it would spend much time oiling and preening its

feathers by running its beak through its plumage. When I chanced to make a noise in the observation box, the bird would suddenly squat down and with an excited look peer out towards the opening of the nest to see what was going on.

At night the young bird slept most of the time, but when daybreak came, it was all alert and very attentive to every noise which in any way suggested the coming of the parent with the customary breakfast. The adult bird when it appeared uttered a peculiar and characteristic "click" as it flew back and forth above the nest before alighting. This call note never failed to excite the little creature to the utmost. As the adult alighted at the edge of the nest the young bird produced a series of guttural chirps, and braced itself back on its legs and tail in preparation for receiving the long expected breakfast.

The food is transferred from the pouch-like gullet of the adult to that of the young by a process of regurgitation. This transfer of food is accompanied by a series of gulps, strains, and wrigglings of the head and neck on the part of both birds.

By the 40th day the young is completely feathered, but down still shows about the region of the head and rump. The tail feathers are now prominent and each shows a black spot near the end of the vein. Ten days later the down is frayed away and the plumage assumes the typical markings of the immature phase of plumage. The black markings are most evident on the wing coverts, scapulars, and inner secondaries, the regions which are destined to become black in the adult. The bill now has a distinctly yellowish color, which continues to deepen to reddish-orange in the older adult birds. From the 50th day (Plate XI, fig. 19) to the 60th day (Plate XI, fig. 20) the black areas of the coverts and secondaries become more continuous, while the black barring of the crown and back become diminished, or rather obscured, by the white tips of the growing feathers. The relative proportions between the wings and the tail have undergone a great change and now approach those of the adult.

The young birds are unable to fly well when they leave the nest, although the wings have been exercised very frequently for some weeks. Those which I observed leaped into the water from the edge of the nest and then made their way out to sea by paddling.

The young birds flopped their wings vigorously, as if attempting to fly, but were never able to rise from the water during the time I observed them. Such an event created considerable excitement among the adult Tropic-birds, which assembled to witness the affair. The young bird while thus floating on the water may be fed by the adults, but more probably depends on its stored fat until it gains enough strength to fly and fish for itself.

## IV. EXPLANATION OF PLATES.

### PLATE III.

Fig. 1. One-Rock Island, a typical island of Great Sound nearly covered with second growth cedars, a few palmettos, and cactuses. Five of the cavities on this side of the island were occupied by nesting birds.

Fig. 2. A close view of one of the cliffs on the outer shore of Morgan's Island, Ely's Harbor. The lower nest is 6 feet above high water mark.

### PLATE IV.

Fig. 3. Adult Tropic-bird in the act of leaving her nest at One-Rock Island. This view shows how the wings may be used in locomotion on land, especially on rough uneven surfaces.

Fig. 4. Adult Tropic-bird on her nest at Tucker's Town. The nest was excavated, probably by the birds themselves, in the side of one of the high sand dunes which run along the shore. The long tail feather is bent over the back of the bird.

### PLATE V.

Fig. 5. Adult Tropic-bird resting in a natural cavity of the cliffs at Bethel's Island.

Fig. 6. Adult Tropic-bird on her nest and egg at Morgan's Island. This nest is made in a thick mat of sargassum which was deposited by the waves.

### PLATE VI.

Fig. 7. Nest and egg of the Tropic-bird at Tucker's Town. Same nest as shown in Plate IV, fig. 4. The egg gave the following measurements: longest diameter 4.9 cm., shortest diameter 3.6 cm., weight 37 grams. The markings on this egg are distributed with comparative uniformity.

Fig. 8. Egg of the Tropic-bird at Two-Rock Island. The measurements

are: longest diameter 5.6 cm., shortest diameter 4.1 cm., weight 40.9 grams.

Fig. 9. Egg pipped and some of the calcareous shell broken away. The shell membrane, however, is intact except where it is pierced by the beak of the embryo. The measurements are: longest diameter 5.4 cm., shortest diameter 3.9 cm., weight before being pipped 44 grams.

Fig. 10. Same egg as shown in fig. 9, but after the shell membrane had been ruptured. In photographing, the head was slightly pulled out to bring the beak into view. The dark patch of down on the crown is noteworthy.

## Plate VII.

Fig. 11. Young Tropic-bird. Age 12 hours; length 11.9 cm.; extent 11.2 cm.; wing 1.6 cm.; foot 2.8 cm.; bill 1.2 cm.; weight 25 grams before receiving any food. Down white, excepting that the crown, regions of wings, rump, and a patch on the back of the neck are tinged with dusky or dull gray. The black skin is naked at the base of the beak, on the lores, on the feet, and on the legs as far up as the heel. The beak and tarsus are a light bluish slate color, the toes and webs of a very much darker slate color. The eyes remain closed for a period of two days.

Fig. 12. Young Tropic-bird. Age 4 days; length 12.7 cm.; extent 11.9 cm.; wing 1.8 cm.; bill 1.3 cm.; foot 2.8 cm.; weight 35 grams. The bird at this age has its eyes open and is very alert and active. The down of the breast is much shorter and thicker than that of other parts of the body. The beak remains a bluish slate color like that of the freshly hatched bird. The oil-gland tubercle is present, but is not yet functional.

## Plate VIII.

Fig. 13. Young Tropic-bird with natural rock background. Age 8 days; length 16.1 cm.; extent 16.7 cm.; wing 2.5 cm.; foot 3.6 cm.; bill 1.4 cm.; weight 92 grams. No feathers have as yet appeared. The legs in their relation to the body have a noticeably posterior position.

Fig. 14. Young Tropic-bird. Age 15 days; length 20.1 cm.; extent 25.4 cm.; wing 3.5 cm.; foot 4.7 cm.; bill 2.0 cm.; weight 145 grams. The various darker regions of the down mentioned in the description of the freshly hatched young are still present, but do not seem to be so sharply differentiated. There is very little down on the sides of the body beneath the wings. In the scapular region have appeared the sheaths of the first quill feathers. These sheaths with their downy tips measure 1 cm. in length. The oil-gland tubercle is now well developed and has two openings, through which the oil exudes when the gland is squeezed. There is no down immediately around the tubercle, but a circlet of hair-like feathers is appearing around its base.

## Plate IX.

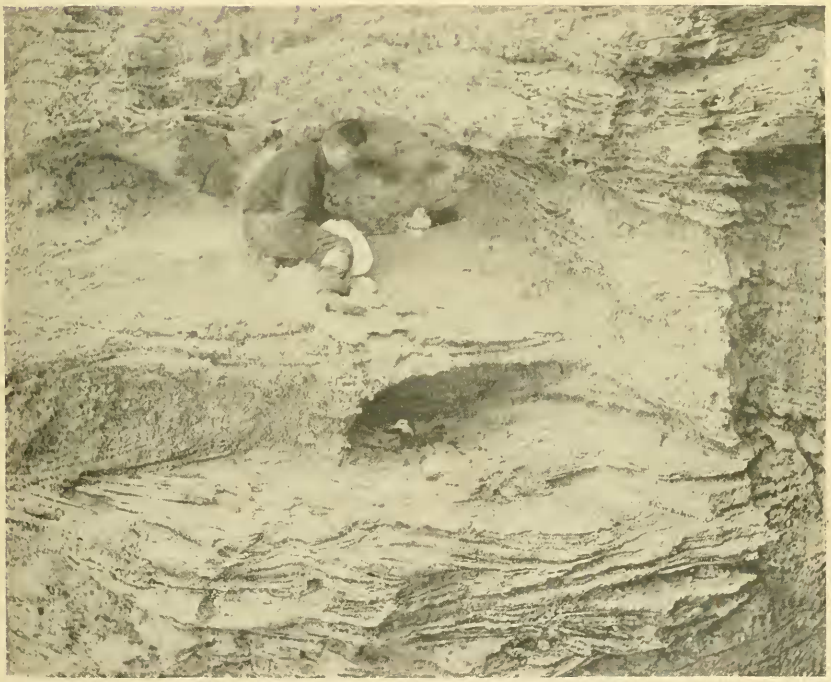
Fig. 15. Young Tropic-bird. Age 20 days; length 22.9 cm.; extent 32.5 cm.; wing 5.5 cm.; bill 2.4 cm.; foot 5.4 cm.; weight 232 grams. This view was taken from a position above the bird in order to show the expanded, barred tips of the first feathers in the scapular region. The sheaths of the feathers of the wings, tail, interscapular region, and breast are appearing through the skin. The skin about the base of the mandibles and lores is dotted with the papillæ of developing feathers.

Fig. 16. Young Tropic-bird. Age 24 days; length 24.3 cm.; tail 1.0 cm.; extent 37.6 cm.; wing 6.9 cm.; bill 2.9 cm.; foot 5.6 cm.; weight 250 grams. The quill feathers have pierced or are piercing nearly every part of the body where such feathers occur. The quills of the primaries and secondaries are so heavily charged with blood that the bird is unable to support its wings continuously, but allows them to rest on the floor of the nest. The tips of the secondaries are expanded and these feathers now range from 2 cm. to 3 cm. in length. The prinaries are not as far advanced as the secondaries. The tail feathers are much slower in their growth than the wing feathers, but at this stage the entire 12 are present. The two feathers destined to become the long tail feathers of the adult are already much longer than the others. These central feathers are 1 cm. in length, but with the tufted downy tips they measure 2.2 cm. The feathers of the breast have expanded tips, but they do not as yet show through the thick mass of down.

## Plate X.

Fig. 17. Young Tropic-bird. Age about 34 days; length 29.8 cm.; tail 3.8 cm.; extent 57.8 cm ; wing 11.5 cm.; bill 3.7 cm.; foot 6.0 cm.; weight 357 grams. The bird at this age, with its alternate areas of down and feathers, and its queer actions, presents a very ungainly and awkward appearance. The feathers in the region of the wings have undergone marked development and now appear as a continuous area of barred plumage. The primaries are white excepting the outer five, which have a black spot or patch in the vein near the tips of the feathers. The secondaries are white excepting the innermost 3 or 4, which are barred with black. The wing coverts are also barred with black. The feathers of the middle of the back are appearing, but are hidden from view by the feathers of the scapular region. The tips of the secondaries and coverts extend back nearly to the region of the oil gland, which is well developed at this stage. The shafts of the tail feathers are black, and each feather shows a black spot near the tip of the vane. The pure white feathers of the breast are well expanded, and replace the mat of down, which has gradually frayed away giving place to this more substantial protective covering. The feathers of the flanks are striped and barred with black as in the adults.

1. ONE-ROCK ISLAND.



2. CLIFF, MORGAN'S ISLAND.